

Refereed papers

Improving collaboration between primary care research networks using Access Grid technology

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ABSTRACT

Access Grid (AG) is an Internet2-driven, high performance audio–visual conferencing technology used worldwide by academic and government organisations to enhance communication, human interaction and group collaboration. AG technology is particularly promising for improving academic multi-centre research collaborations. This manuscript describes how the AG technology was utilised by the electronic Primary Care Research Network (ePCRN) that is part of the National Institutes of

Health (NIH) Roadmap initiative to improve primary care research and collaboration among practice-based research networks (PBRNs) in the USA. It discusses the design, installation and use of AG implementations, potential future applications, barriers to adoption, and suggested solutions.

Keywords: access grid, practice-based research networks, primary care

Background

The ePCRN Project

PBRNs have been around since the early 1970s in the USA, but have only recently received significant attention from funding agencies and the medical community. One of the most significant government agencies that

support PBRNs is the Agency for Health Care Research and Quality (AHRQ) that defines PBRNs as ‘a group of ambulatory practices devoted principally to the primary care of patients, and affiliated in their mission to investigate questions related to

community based practice and to improve the quality of primary care.' The ePCRN is a national PBRN that allows primary care practices to link with researchers conducting clinical research anywhere in the USA via the internet.¹ This programme is funded by the Roadmap initiative of the NIH, and administered by the Federation of Practice Based Research Networks (FPBRN). Integrating cutting-edge technology and clinical research, the ePCRN is a promising infrastructure development in primary care practice-based research. One of the goals of the ePCRN project is to develop and maintain an advanced audio-visual conferencing system between PBRNs using Access Grid technology.

The AG technology

AG is an emerging internet-based technology that employs existing or specialised computer hardware, advanced communication software and a dedicated, high-speed academic backbone called Internet2. This allows clinical sites to install an advanced audio-visual communication environment that can be made available to the sites for a minimal cost. The AG technology has been utilised very successfully worldwide by academic and healthcare institutions, government entities, companies and non-profit organisations that require frequent group collaboration.^{2–4} Currently, over 200 academic and government institutions are members of the AG community in the USA. AG provides outstanding audio-visual quality that simulates the experience of face-to-face meetings in an integrated communication environment that greatly enhances virtual collaborations. With features that include up to

256 Kb/sec/client audio transmission, over 1 Mb/sec/client video transmission and secure data and application sharing, AG is one of the most advanced technologies available for audio-visual collaboration. An image taken at an ePCRN network directors meeting over the AG is shown in Figure 1 and a typical collaboration setup outline is demonstrated in Figure 2. Although AG has been designed to operate through high-speed internet connections (e.g. academic networks or national Internet2 backbone), it can also use conventional connections (e.g. T1 lines, cable, or even DSL), albeit with a reduced image and sound quality.

- **AG Venue Server** the AG Venue Server connects participants and manages audio, video and data sharing throughout the network grid.
- **Internet2** an advanced and significantly enhanced Internet backbone dedicated to academic entities.
- **Personal AG Node** a single computer (desktop or laptop) equipped with a web camera and a headset or echo-cancellation conference microphone.
- **Small Group AG Node** a computer 'station' designed for a small number (2–3) of participants in an AG session.
- **Large Group AG Node** a dedicated conference room with one or multiple video cameras and high quality audio equipment for a group of participants who participate in AG collaboration.

The advantages of the AG technology

Besides AG, a number of applications, both open source and commercial, are available to provide various levels of video conferencing. These solutions range from

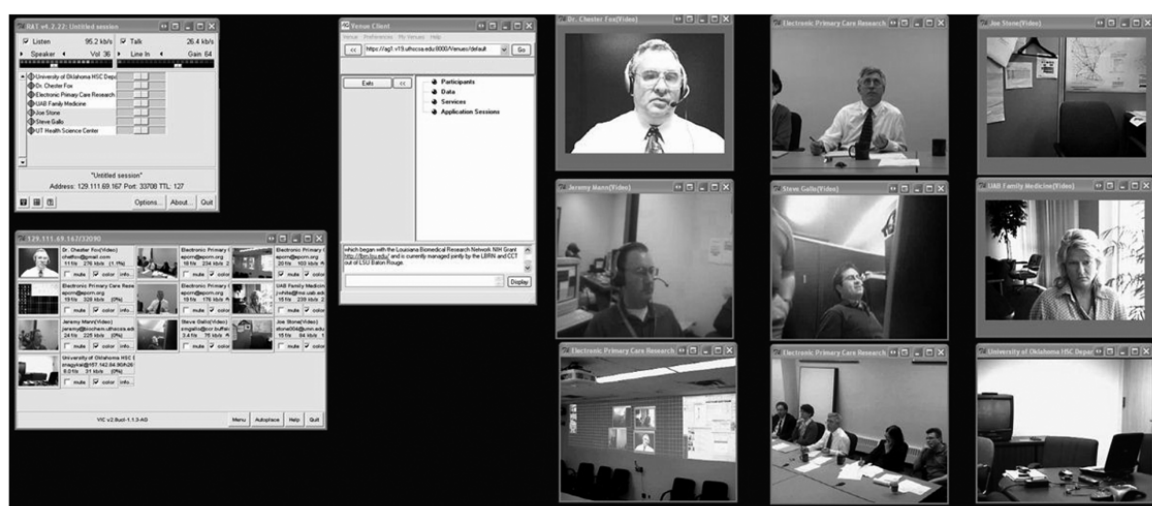


Figure 1 A representative ePCRN group collaboration meeting as it is shown on one participating site's computer screen. AG audio and video controls are depicted on the left, while tiled video images from individual group locations can be seen on the right.

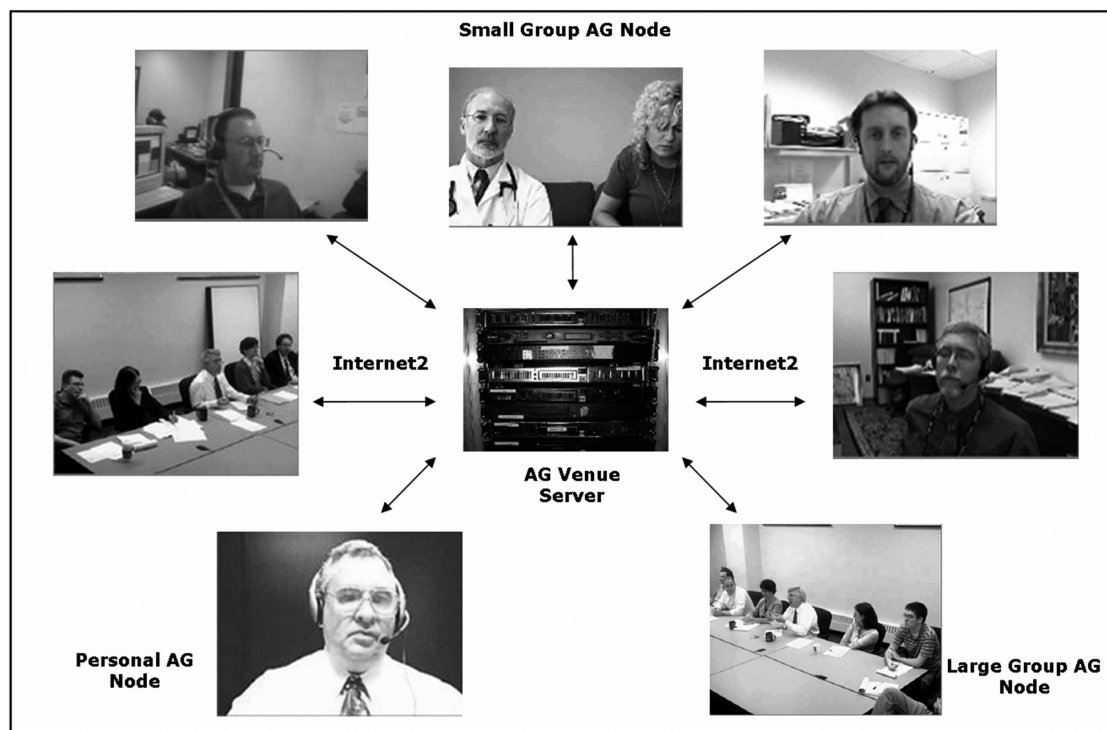


Figure 2 Schema of an Access Grid audio-visual collaboration session. Clients connect to a Venue Server (centre image) over the Internet securely through a software interface (Venue Client). The Venue Server distributes audio, video and application data information (e.g. presentation slides, browser sharing, desktop sharing, etc) to participants who can effectively and easily communicate in a virtual meeting space

simple internet browser-based applications that support one-on-one meetings where audio and video are often not integrated into one environment to more advanced systems that can deliver fully interactive group meetings. AG technology substantially differs from most of these solutions in robustness, audio-visual quality, scalability and flexibility, making AG very attractive for academic entities intending to engage in large group research collaborations. While high-grade commercial group conferencing tools are usually pricey, a version of the AG software is freely available in an open-source solution that incorporates both server and client applications. The open-source version is considerably more flexible than most other software, since some portions of the code can be easily altered to tailor the system to the needs of individual users. Modifying the software requires some programming knowledge, however there is a significant support community for open-source developers who share a variety of enhancements at no cost. Maximum flexibility is a key feature for making a communication solution successful, because each meeting participant has a very different local environment and has to meet requirements that are specific to the local infrastructure.

ePCRN demonstration project (Measuring Outcomes of Clinical Connectivity trial)

Multi-centre trials require significant co-ordination among project sites, and AG technology can be a valuable and effective tool for that purpose. For example, in the first randomised clinical trial conducted by the ePCRN, the MOCC trial, 12 geographically dispersed PBRNs recruited 100 clinicians to test the ePCRN's data collection system. PBRN directors and co-ordinators met monthly for nine consecutive months from April to December of 2005 via AG conferencing (before and during the trial) to undergo training, develop contracts and monitor recruiting efforts. Throughout the process, AG technology facilitated the discussion of complex topics such as how to recruit and train PBRN members to register with the ePCRN Connectivity Demo and how to design forms and procedures for the electronic trial (MOCC trial). The Connectivity Demo went live on July 15 and the MOCC trial began on November 14.

Three networks were the first adopters of the AG technology: Minnesota, Buffalo NY and Oklahoma networks were all participating via AG by October

2005, while other networks were still calling in by phone. Participation in AG sessions corresponded with success in recruiting goals for the MOCC trial. The three lead adopter PBRNs had all met or exceeded their recruiting goals by October. On the other hand, networks that did not get an AG node running did not meet the recruiting goals of the MOCC trial. These networks included the State Network of Colorado Ambulatory Practices and Partners (SNOCAP) and the National Research Network (NRN) that never installed an AG node, the South Florida PBRN (SoFlaPBRN) that installed a node after the MOCC trial was over and the South Texas Ambulatory Research Network (STARNet) that did not join the AG group until December. Overall, as a result of the enhanced communication, the MOCC trial was completed successfully in less than seven weeks.⁵

Implementing the AG technology in primary care research

Enhancing national research collaborations among PBRNs

The collaborative meetings before and during the ePCRN MOCC trial showed that AG technology is a unique tool for enhancing group collaboration in the virtual space. In the course of building up the national AG network some PBRN sites were not able to implement the AG technology immediately and joined administrative meetings via regular phone. This provided an opportunity to compare the experience of conventional phone conferencing to an AG meeting. Personal feedback from participating sites indicated that PBRN directors and network representatives could relate to each other and to the project significantly better when their experience approximated a true face-to-face interaction. Social interaction was greatly enhanced when AG technology was implemented. This had a substantial effect on the efficiency of group meetings and the entire project. Areas of improvement included meta-communication (visual cues and body language), face recognition, group-level interaction and feedback (e.g. voting by raising hands), synchronisation of participation (e.g. participants could indicate their intention to speak) that decreased the number of interruptions, ease of communication (e.g. no static noise) and the possibility of unintrusive private communications during group meetings.

At the time of this publication 12 PBRNs are connected to the national ePCRN network and several more will be connected in the near future (Table 1). These PBRNs also participated in the ePCRN MOCC

trial and utilised the AG technology to communicate and participate in regular administrative meetings.

Enhancing state and local research collaborations within PBRNs

In addition to the national ePCRN collaboration, some PBRNs established a local network of connected primary care practices utilising the AG technology. The Oklahoma Physicians Resource/Research Network (OKPRN), for example, connected over a dozen clinicians throughout the state to enhance communication and save time and money associated with travel. OKPRN employs practice facilitators called Practice Enhancement Assistants (PEAs) who visit a group of practices regularly to work on research and quality improvement projects, including the ePCRN project. By using AG technology, PEAs across the state are able to participate in weekly administrative meetings to discuss projects, receive training and share 'best practice' ideas and solutions they encounter in their practices in a fully interactive manner. Nagykaladi *et al*^{6,7} have recently authored several publications on the role of practice facilitators in primary care. The AG technology has also been used to facilitate PBRN board and committee meetings (e.g. board of directors, health IT committee, project advisory and development committee etc). AG helps rural clinician members to contribute to the work of the PBRN leadership and ensures that the network incorporates bottom-up initiatives. Additionally, OKPRN provides Continuing Medical Education (CME) activities for clinician members over the AG. The idea of saving considerable time and cost with interactive audio-visual CME conferences has been very popular among OKPRN clinicians who practice at remote locations.

Resources for learning about the AG technology

Several web sites provide an excellent resource for learning about the AG technology. The Argonne National Laboratory (www.anl.gov), a US Department of Energy laboratory managed by the University of Chicago and one of the developers of the AG technology, maintains an informative and resourceful web site at www.accessgrid.org. This web site has detailed information on the background, utilisation and implementation of the AG technology along with an array of software resources, manuals, tutorials and instructions. The AG Toolkit and its documentation is available at www-new.mcs.anl.gov/fl/research/accessgrid. The AG community also provides a meeting scheduler (<http://agschedule.ncsa.uiuc.edu/default.asp>) and several

Table 1 Primary care PBRNs participating in the ePCRN project using AG technology

Network	Description
AAFP NRN (National)	Nationally distributed network headquartered in Kansas City, MO with 312 providers in 200 clinics serving over 500 000 patients
APBRN (Alabama)	State-wide network with 30 providers in 20 clinics serving 250 000 patients
CaReNet (Colorado)	State-wide network with 508 providers in 33 clinics serving 300 000 patients
HPRN (Colorado)	High Plains serves the rural plains of Colorado, Nebraska and Kansas with 70 providers in 20 clinics serving 100 000 patients
INET (Indiana)	State-wide network with 123 providers in 80 clinics, including 12 primary care residency sites serving approximately 235 000 patients
LANet (USC, California)	A network specifically focused on healthcare disparities in LA County, includes 250 providers in 16 clinics serving 170 000 patients
MAFPRN (Minnesota)	State-wide network with 184 providers at 101 clinics serving 350 000 patients
UNYNET (New York)	Regional network serving western New York with 62 clinics serving 228 000
OKPRN (Oklahoma)	State-wide network with 230+ providers in over 90 clinics serving 350 000 patients. Utilises PEAs to facilitate projects
PSARN (Penn State)	Regional network serving south-central Pennsylvania. Includes 138 providers at 23 clinics serving 180 000 patients
SoFlaPBRN (Florida)	Regional network serving a four county area of South Florida. Includes 42 providers in 37 clinics serving 80 000 patients
STARNet (Texas)	Regional network serving South Texas. Includes 30 providers in 24 clinics serving 48 000 patients

email lists with ongoing education for users. Since this project is open source, programmers and enthusiasts can also learn about how to customise their system at the code level. The 'Communication Tools' section of the ePCRN website (www.epcrn.org) lists presentations, instructions and other resources that can help PBRNs learn about utilisation of the AG technology in primary care and then set up AG connection points, called 'nodes'. For a more comprehensive AG resource list, please refer to Table 2.

Basic system requirements

The AG Venue Client software does not have one standard hardware setup, users have been experimenting with it on many different hardware configurations and operating systems (e.g. Windows, Linux, Mac OS, etc). On Windows platform, an ideal personal interface to the grid (PIG) runs on Windows XP SP2 with 2GHz or faster CPU and 512Mb RAM. Installation of the AG Toolkit v2.4 and later versions requires administrative

privileges. To participate in small meetings (2–3 participants), at least a Digital Service Line (DSL) Internet connection with over 1 Mbit/sec bandwidth is required, while cable or faster connections (over 3–5 Mbit/sec) provide significantly better video quality. Larger meetings (5–15 participants) can be managed only through T3 or better connections that are typically available at academic sites or other large institutions. PIG nodes can run on a simple laptop or desktop with a web camera and a headset or echo-cancellation conference microphone. Room-size nodes that can accommodate a group of participants require a more substantial audio–visual setup depending on the size of the room. AG users experimented with the technology using mobile devices (wireless PDAs and Tablet PCs) as well. The description of Venue Servers and Bridge Servers goes beyond the scope of this publication. However, individual organisations can also use pre-configured servers that are freely available to the academic community (e.g. at the National Center for Supercomputing Applications – NCSA) to host virtual meetings.

Table 2 Resources for planning, implementing, and maintaining AG technology in PBRNs

Resources	Resource Urls
Argonne National Laboratory	www.anl.gov
AG Toolkit and Documentation	www-new.mcs.anl.gov/fl/research/accessgrid
AG Technology and Registration	www.accessgrid.org
AG Meeting Scheduler	http://agschedule.ncsa.uiuc.edu/default.asp
AG Resources for PBRNs	http://epcrn.org (Communication Tools section)
AG Wiki	www-new.mcs.anl.gov/fl/research/accessgrid/wiki/moin.cgi
AG FAQ	www.accessgrid.uthscsa.edu/faq.html
AG Mailing Lists	www-fp.mcs.anl.gov/fl/accessgrid/technical.htm

Learning to install and configure the Venue Client

Installation and operation of the open-source Venue Client solution has a learning curve, but once familiar, users can easily navigate the system. Installation is usually simple, users can follow instructions spelled out in materials that come with the software or are available via the 'Communication Tools' section at www.epcrn.org. However, configuration of the client may require a more intricate process depending on the actual setup and the way one intends to use the system. As a rule of thumb, available bandwidth determines the default audio and video settings in the Venue Client software. For example, if one plans to operate a personal node over a DSL connection, switching to a bandwidth-sparing audio codec (e.g. GSM) becomes absolutely necessary. Similarly, frame rate and quality of the video feed must be set appropriately by each participant, even if only one participant has a limited connection. Fortunately, these settings can be adjusted and saved either in the Venue Client, or within the application code (by more advanced users). To provide a simple turn-key solution that most computer users can install without extensive configuration, ePCRN has designed install packages and corresponding documentation materials that are available under the 'Communication Tools' section of the ePCRN website (www.epcrn.org).

Technical barriers

Most recent computers should be able to handle the latest versions of the Venue Client software (versions 2.4 and 3.0). On the other hand, users may encounter significant barriers while connecting the Venue Client through tightly controlled academic or corporate

networks, especially in medical schools and hospitals, where protected health information (PHI) may be present on computers. Current versions of the AG software require free, two-way communication through a wide range of User Datagram Protocol (UDP) ports that are usually blocked by firewalls. There are various solutions to provide network support for the Venue Client, but careful planning and extensive communication with institutional IT staff will most likely be critical for the success of the project. Indeed, proper understanding and utilisation of the technology by all involved parties (users, network support personnel, administrators and institutional decision makers) has been the most important factor in integration of AG technology into an existing infrastructure. In order to help AG users in institutions with the most restrictive firewalls, ePCRN has recently developed a Virtual Private Network (VPN) solution using open-source software (OpenVPN) that is able to connect clients through firewalls where UDP ports are blocked. Technical information about local network configurations and the VPN solution can be found at www.epcrn.org.

Personal and logistical barriers and solutions

As we mentioned above, institutional and logistical barriers may be significant, particularly in medical schools. PBRNs in the ePCRN project found that the most effective way to overcome these barriers was to include strategically all professionals and decision makers in the planning and implementation phase of the project. AG technology is still emerging and there are alternative solutions that may be better known, but less suitable for the type of projects on which primary care networks and clinic sites wish to embark. It is essential therefore that implementation of the AG

technology is preceded by careful learning and dissemination of information and followed by group planning that involves all stakeholders identified in the process. Adaptations, protocols and system templates developed by other institutions can be very helpful for users new to the AG technology. Both the AG community and ePCRN resources referenced in this article provide a significant amount of information on presentation projects that can be modeled in new AG installations. This information empowers new users to avoid common pitfalls and overcome barriers in a timely manner.

Security and conduct

The AG technology complies with the requirements of privacy and security regulations (e.g. HIPAA) with regards to the transmission of potentially sensitive personal information. AG sessions are established over a Secure Socket Layer (SSL) connection utilising client certificates issued by the Argonne National Laboratory that identify each connected participant. In addition, audio and video streams can be encrypted to prevent man-in-the-middle attacks. Furthermore, accessibility of the virtual meeting space ('venue') can be restricted to registered and authorised members of the AG community.

The AG system is built on credibility and mutual trust between academic organisations that use a technology that has been developed and sustained by federally funded national laboratories. Participants are expected to abide by the regulations pertaining to professional academic conduct that are mandatory in regular conferences and meetings.

Lessons learned

Successful and timely implementation of the AG technology requires systematic information gathering and careful planning to avoid common pitfalls and misunderstandings that can jeopardise the adoption of the technology. Since AG can be used in a variety of ways and for different purposes that require distinct implementation models, it is essential for users to have a clear vision of what they intend to accomplish with this technology. They should also thoroughly explore available resources and possible barriers to implementation. It is highly recommended that they consult with established AG community members and 'best practice' exemplars on how to install and improve AG networks in a primary care setting. The ePCRN has substantial expertise and experience to help other networks and users explore their options. A crucial step in the process of adopting AG technology is to include strategically all decision makers and affected

parties in the early phase of planning and then in the execution of plans.

Cost of implementation, maintenance, and fund-raising for AG installations

Some PBRNs have been able to secure funds to design and establish room-size and personal AG nodes that can be used to connect their networks to other national organisations and also to individual members of their own network. Support typically came from academic infrastructural and research grants or contracts. OKPRN, for example, received a US\$10 000 infrastructural grant from the local Presbyterian Health Foundation to build a small room-size node in the University of Oklahoma Health Sciences Center, Department of Family Medicine. This grant also covered web cameras, headsets and additional electronic equipment for 25 personal nodes to establish AG connections between OKPRN practice sites. The grant required that in addition to OKPRN projects, the room-size node must be made available for other entities in the Department and on campus upon request, in order to participate in audio-visual collaborations. Assuming that a basic IT infrastructure is already available (computers and high-speed internet access), a typical personal or small group AG node costs less than US\$100, while a more advanced, room-size node may cost between US\$3000 and US\$10 000 depending on existing equipment (e.g. video projector, screen, audio system) and particular requirements for quality.

Future potential

Our experience suggests that AG technology has a significant potential for future collaborations between networked clinicians and federal entities such as the various organisations in the NIH, the AHRQ and the American Academy of Family Physicians (AAFP). Traditionally, some federal organisations had very limited direct access to primary care clinicians and research data collected in clinician office settings during the course of regular care, although current efforts that aim at closing the gap between research and practice clearly require these connections. AG technology has the potential to significantly improve direct communication between federal agencies and primary care providers and enhance the administration of practice-based clinical trials on a national scale.

Another intriguing and very timely area for AG utilisation is the possibility to complement existing communication channels in national bio-surveillance and first-line responder networks. It is essential that surveillance networks can shift from early detection to

emergency administration without delay. Recent shortcomings of communication systems after Hurricane Katrina indicate that there is plenty of room for improvement in communication technologies on the federal, state and local level. As an example, during the 2003 Sudden Acute Respiratory Syndrome (SARS) virus outbreak in Taiwan, AG technology enabled radiologists from across the country to review patients' X-rays without added risk of infection.⁸ Connecting groups of primary care clinicians directly to federal healthcare agencies could improve the access of decision makers to real-time information and enhance the timeliness of feedback both in the course of regular activities and in biomedical emergencies. Our experience suggests that Access Grid technology could be a viable candidate to bridge this communication gap.

It has been suggested that primary care clinicians could obtain CME credits via convenient and interactive AG sessions. Various on-line CME options are already available, but few of them provide the level of interactivity possible with AG technology. For example, when watching an on-line or off-line video presentation, clinicians are not able to ask questions from the speaker to clarify issues or to obtain additional insights. Full interactivity is regularly achieved in face-to-face meetings that are usually costly to organise or to attend due to travel expenses and time. AG meetings, on the other hand, can bring speakers from a central location into the very environment where clinicians practice or live in a fully interactive format.

Conclusions

AG technology can significantly enhance group collaboration between primary care clinicians and PBRNs. In the MOCC trial, the AG technology has been an effective way of improving social interaction and group collaboration that has new and intriguing implications for primary care networks. ePCRN and other PBRNs have demonstrated the feasibility and usefulness of the technology in enhancing primary care research in pilot implementation projects. The primary care research environment requires special solutions that are being developed by ePCRN and other PBRNs. AG technology has a substantial potential to open novel and more effective venues for communication and collaboration in primary care research.

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CONFLICTS OF INTEREST

None.

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